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PROFESSIONAL COMPETENCIES OF SPECIALISTS IN THE DEVELOPMENT OF COMPUTER GAMES

Abstract. The computer game development industry has become an important and rapidly growing sector of the global digital economy, which requires a comprehensive understanding of the professional competencies of game engineering professionals. The study examines the models of skills, knowledge, and dispositions required by game application development specialists. They were derived from analysing domestic and international educational programmes, industry standards, and professional frameworks.

The article uses a methodology that includes a literature review, observation and analysis of specific situations, and design of pedagogical systems and models. The study identifies and synthesises the structure of professional competencies in several key dimensions: technical, cognitive, creative, interpersonal, and managerial. A proposed model combines these dimensions into a structured system that emphasises the interrelated nature of the knowledge, skills, values, and beliefs required for in-game project engineering. The model emphasises the importance of an interdisciplinary approach, combining technical, soft skills and creativity.

The results of the study have important practical implications for stakeholders. The developed model provides insights into targeted learning strategies for computer science and software engineering students. Higher education institutions can use it to develop more comprehensive and production-oriented educational programmes.

The study main limitations are the focus on formal university education and potential technological limitations in implementing integrated curricula. The study suggests that cloud computing and virtual reality technologies can mitigate some of these limitations by offering innovative solutions for skills development.

Keywords: game projects engineering; professional competencies in game application development; model of professional competencies.

INTRODUCTION

Today, the gaming industry covers many fields, including game development, game visual effects, related multimedia resources, and much more. Each of these areas requires a high level of professional competence, which includes the knowledge, skills, and experience necessary to perform tasks in this industry. Experienced specialists in the field of game application development must have knowledge and skills in game development technologies, programming, relevant algorithms and mathematical principles necessary for successful professional activity. In addition, they should have in-depth knowledge of design, animation, sound, graphics, and other areas that are part of the gaming industry. Project management, communication, teamwork, and other social skills are also critical. Game project engineering specialists are in high demand in the modern world, as the gaming industry is growing every year and becoming increasingly important for developing the global economy. Since the development of the gaming industry requires highly qualified specialists with a variety of competencies necessary for the implementation of gaming projects and their support, the study of the essence of professional competencies and their standardisation is quite relevant today.

This paper aims to study the professional competencies of game application development specialists and identify the key ones necessary for successful professional activity. **The objectives of the study** are as follows:

1. An overview of domestic and foreign experience in training specialists in the development of game projects.
2. Identification of key competencies: The study will help identify a set of key competencies required for effective work in the field of game engineering.
3. Designing a model of professional competencies of game application developers and summarizing the practical significance of these competencies for individual stakeholders.

The object of research is the process of training future specialists in game project engineering.

The subject of the study is the professional competencies of specialists involved in the development, design, testing, and deployment of game projects, as well as the factors that influence their development, including work experience, organization culture, motivation, etc. The subject of the study includes the personal qualities and professional skills of specialists and organizational processes and strategies that determine the requirements for competencies in the industry. In addition, the subject of the study is various aspects of game projects that affect the competencies of specialists, such as the variety of genres, technologies, and platforms that specialists in this field work with. The study covers both technological aspects and aspects of design, project management, and marketing.

The research was carried out in the joint laboratory of the Institute for Digitalisation of Education at the National Academy of Educational Sciences of Ukraine and Ternopil Volodymyr Hnatiuk National Pedagogical University (Ukraine).

METHODS

The methodology of this study follows generally accepted processes such as identifying the research problem, literature review, formulating hypotheses, and developing the model of professional competencies of specialists in the development of computer games. Since this research is not limited to one article, its other stages (experiment, data collection, data analysis, and drawing general conclusions) are also included in the study methodology. Accordingly, the following methods were used in the research process of this article:

1. Analysis of the system of competencies offered by educational and professional training programs in this field at different universities and systems of competencies in different qualification frameworks and standards.
2. Observation: Observing specialists while working on game projects makes it possible to assess their skills and abilities in action and identify potential limitations and challenges they face.

3. Case studies: researching specific cases of successful game projects can help identify the key competencies that led to the project success.

The general hypothesis of the entire study indicates that the use of the author's model and partial methods of training specialists in the field of computer game development developed on its basis are effective ways of forming their professional competencies. At the same time, the partial hypothesis of this article is that a comprehensive analysis of the sources will allow us to identify stable provisions that will become the basis for the construction of a model of the formation of professional competencies of future specialists in the development of computer games.

THE LITERATURE REVIEW

Since the early 2010s, game development training has become a significant area of study in computer science and educational technology due to the growing popularity of games and their potential as educational tools. As a result, developer training models have been designed. According to one of them, game development is a process of gaining experience in which students acquire knowledge and develop skills through practical participation [1].

This approach is based on constructivist learning theory. It emphasizes hands-on learning and iterative design processes. An effective learning strategy within this approach is using repetitive learning activities [2]. Iterative design processes help students improve their skills through repeated testing and feedback, which is in line with the professional activities of game developers. Researchers use the project-based learning model in teaching game design and development. This method allows students to work on real projects, which improves their algorithmic skills and understanding of game development principles. In such projects, students often work in teams, which develops communication skills and provides diverse perspectives on problem-solving [2].

Other studies focus on analyzing and selecting tools and platforms for developing game applications. The publications [3; 4] offer to teach the Unity and Unreal Engine game engines. The authors note that these tools provide professional-level features that can be adapted for educational purposes.

Authors [5; 6] discuss the use of visual programming languages and environments (Scratch, Blueprint) in teaching game development. These tools are accessible to beginners and facilitate learning programming concepts.

Regarding the effectiveness of the game development process, research shows that the educational process can have ambivalent consequences. Positive learning outcomes include the development of problem-solving skills, the ability to decompose problems, debug code, and repeatedly improve their projects [7; 8]. There is also an increase in student engagement and motivation, as the interactive and rewarding nature of games attracts students and encourages them to persevere with their learning tasks [9; 10; 11]. Despite the benefits, there are challenges to teaching computer game development. These include the complexity of the design and development processes. The author of the article [12] emphasizes that the complexity of game development can overwhelm students, especially beginners. In this regard, teachers need to balance the scope of projects and provide adequate support.

There are also difficulties in assessing student learning outcomes in game development disciplines. Traditional assessment methods may not cover the full range of skills that students develop through game projects [13]. As a result, there is an objective need to develop criteria and indicators for evaluating game applications that are the results of students' project activities.

EXPERIENCE IN TRAINING SPECIALISTS IN COMPUTER GAME DEVELOPMENT

Educational programs are being launched in Ukrainian higher education institutions to train specialists in the gaming industry. In particular, in 2019, Volodymyr Hnatiuk Ternopil National Pedagogical University launched the educational and professional program "Game Projects Engineering" of the first (bachelor's) level of higher education in the speciality 122 "Computer

Science" of the field of knowledge 12 "Information Technology" [14]. This was an innovative project within Ukraine: there was no specialization for the speciality 122 "Computer Science" in Ukraine.

Currently, in Ukraine, the formation of competencies in game projects development is also carried out within the specialty 121 "Software Engineering". For example, Sumy State University has launched an educational program "Esports and Computer Game Development". Its main task is to train specialists capable of setting and solving tasks related to the modelling of game applications, the use of strategies and tactics of computer gaming, data analytics, networking, event management, planning and organization of gaming and esports competitions [15]. In 2024, Zhytomyr Polytechnic State University is launching the Computer Graphics and Game Development educational program [16]. The draft program focuses on applying mathematical methods and algorithmic principles in modelling, designing, developing, and maintaining information technologies; developing, implementing, and maintaining intelligent systems for analyzing and processing data of organizational, technical, natural, and socioeconomic systems.

Foreign universities also have considerable experience training specialists in designing and developing computer games. For example, Tokyo University of Technology has developed a corresponding educational program since 2010. It provided for the development of practical skills in the development of computer games through training in the three main components of game creation, such as: design (game design, mechanics, user experience), development (programming, graphics, sound, documentation, presentation), and game projects management (production, marketing, product evaluation) [17]. The authors emphasize the importance of cooperation between the university sector and interested business organizations (IGDA), as well as in creating a model for training specialists and developing an appropriate educational environment. Such universities offer specialized programs in game design and development as:

- The University of Southern California (USC) offers bachelor's and master's programs covering game development, interactive media, and related technologies.
- DigiPen Institute of Technology (Redmond, Washington) offers Bachelor of Computer Science in Interactive Modeling and Bachelor of Arts in Game Design programs.
- The University of Utah offers an educational program in game design called "Entertainment Art and Engineering".
- Rensselaer Polytechnic Institute (RPI) offers programs in game design and game modeling. Students can earn a Bachelor of Science degree with various specializations, including game design, development, and art.
- Full Sail University offers a comprehensive bachelor's degree program in game development that can be completed both on campus and online. The program focuses on the full game development cycle from preproduction to finished product.

Worldfamous universities (such as Stanford, Iowa State University, Massachusetts Institute of Technology, and Carnegie Mellon University) offer both individual courses and training for students in laboratories or educational projects. Let's briefly describe some of them. The Game Lab at the Massachusetts Institute of Technology offers students opportunities during the school year on active research and development projects for MIT undergraduates [18]. The Game Lab staff regularly teaches game studies, design, and development courses. Stanford University has developed a course CS 146: Introduction to Game Design and Development. The main teaching method in the course is project work. The course is an introductory and basic introduction to game design, covering such topics as 2D/3D art, audio, user interfaces, production, narrative design, marketing, and publishing. The course culminates in students forming project teams to develop a final video game [19]. An important factor in learning to create game applications at foreign universities is their cooperation with internal and external organizations (companies, NGOs, etc.). Partners of such projects often turn to academic institutions for their experience in game research, design, and development.

Internationally, several organizations develop and promote competencies for game projects engineers. Here are some of them:

1. The International Game Developers Association (IGDA) develops the professional community of game developers and advocates for standardising professional competencies. They offer recommendations on what a game developer, including engineers, should be able to do.

2. The Joint Task Force on Computing Curricula (JTFCC) is a group of experts from academia and industry that develops competency standards for information technology, including game engineers.

3. European Game Developers Federation (EGDF) represents the interests of game developers in Europe and develops standards for various professions in the field of game development, including engineers.

4. International Game Developers Association Foundation (IGDAF) This foundation organization, affiliated with IGDA, aims to develop the professional community of game developers and support the development of competencies in the field of game development, including engineers.

5. International Society of Game Studies (ISGS) is engaged in the development of the scientific base for gaming and teaching "game studies", which defines the competencies necessary for the study of gaming and game engineering.

Ukraine also has its own organizations engaged in research in Game Studies.

Here are some of them:

1. The Institute of Media, Information Technology and Free Press is an organization that offers a master's program in Game Studies in Kyiv. The program focuses on the study of game culture and interactive environments.

2. Lviv Game Research Network is a group of researchers from Lviv who study game technologies and game culture. They organize various events, such as seminars, conferences and trainings, to help develop the field of Game Studies in Ukraine.

3. The Ukrainian Game Industry Association is a professional organization that deals with the development of the game industry in Ukraine. The association consists of researchers, game developers, investors, and other stakeholders who work to raise awareness of the game industry and support its development in Ukraine.

4. The East European Association for Game Studies (EEGS) is an international association that gathers researchers from Central and Eastern Europe who study game technologies and game culture. EEGS organizes conferences and other events to support the exchange of ideas and promote the development of the field of Game Studies.

EGDF participated in a project funded by the European Commission to develop a qualification framework for game development. The result of this project was the European Qualification Framework for Games Development (EQF-GD), which defines the knowledge, skills and competencies that employees in the game development field should have at different levels. The EQF-GD describes the knowledge, skills and competencies required to work in the field of game development. It consists of 5 levels, each of which describes the level of complexity, knowledge and skills required to work in the field. At the same time, research was conducted on the essence of the competencies that game industry professionals should have [20] and certain disciplines directly related to game project engineering were introduced into the educational process [21]. In this publication, authors have experience researching professional competencies and ways to form them for other specialities [22].

RESEARCH RESULTS

The latest Computer Science Curricula treat competence as a set of interrelated dimensions such as knowledge, skills and dispositions. Knowledge designates an awareness and understanding of core concepts and content. Skills refer to capabilities and strategies that develop over time through deliberate practice and interactions with others. Skills also require engagement in higher-

order cognitive activities. Dispositions encompass socioemotional skills, behaviours, and attitudes that characterize the inclination to carry out tasks and the sensitivity to know when and how to engage in those tasks [23]. These dimensions correspond to the questions the student needs to answer, namely 'know-what', 'know-how' and 'know-why'.

As a result of the analysis these documents and some literature sources [2; 24; 17; 25], generalization of the experience gained in the process of implementing individual game cases [26], [27] and as a result of communication with industry professionals and students, we can formulate the following competencies necessary for the successful work of a game projects engineer:

Understanding game mechanics. A game engineer should have a deep knowledge of game mechanics, such as physics, character control, collision mechanics, collisions, and effects. Mechanics define the algorithms of interaction within the game environment, and it is important for determining the "player experience" through the dynamics of the gameplay and the emotional involvement of the user. The development of this competency will allow developers to create multiplayer modes, adjust the complexity of levels and implement a reward system. A deep understanding of mechanics will enable developers to optimize applications for performance and identify and fix errors at different stages of project development. A skilled developer should understand how a particular mechanic integrates with other game design elements, such as narrative, art style, and sound design. Such mechanics will enhance the overall theme and feel of the game.

Understanding of programming. Programming skills will allow a game projects engineer to develop functional game components, including interface, graphics, sound, and user interaction. Programming skills allow developers to turn game design documents into working code. This ensures the implementation of game mechanics, physics of interactions, user interfaces, etc. Effective use of programming methods allows for quick prototyping. Knowledge of programming languages is necessary to identify and fix code errors. This competency is also important for the development of game graphics, which involves the implementation of scene visualization algorithms such as lighting, shading, and texture mapping. Well-designed algorithms and code structures make it easier to update and expand games in the future with patches, add-ons, or sequels. Efficient code is easier to maintain, reducing maintenance costs and making future maintenance more manageable. Many game development problems can be solved with the right algorithms. These include improving load times, creating realistic physics, or developing complex AI behaviour.

Understanding of graphics. Knowledge of the basics of graphic design and related programs will allow a game engineer to create visual effects and game objects. This competency goes beyond the simple perception of visual effects. It involves the use of visual effects to communicate, create atmosphere, and ultimately improve gameplay effectively. Graphics are often the first impression a player has of a game. Attractive visuals can grab the attention of players and arouse their interest. A deep understanding of visual design principles, such as colour theory, composition, and lighting, allows developers to create aesthetically pleasing game environments that set the tone and mood of the game. Clear and well-designed visual effects are intuitively and correctly perceived by users. A competent graphics developer is able to optimize visual elements, which ensures a smooth operation of the gaming application on different devices and hardware. This involves the use of efficient 3D models, smart texture management, and an understanding of graphic rendering techniques.

Understanding artificial intelligence. In the game development industry today, artificial intelligence offers new possibilities for gameplay, world-building, and ultimately project development itself. Knowledge of artificial intelligence will allow game engineers to create intelligent opponents that can react to user actions. Already, AI can create new levels, quests, or game objects using procedural content generation, making the gameplay exciting and unpredictable. AI technologies can analyze user behaviour and adjust the complexity of the game accordingly. A modern developer can use AI to create new game stories and narratives. Such dialog systems with artificial intelligence can create branched storylines, character interactions, and unexpected situations, which leads to unique and unforgettable moments for users. The use of AI is also important for automating application testing processes to detect bugs and unbalanced moments of the game.

Understanding multiplayer. A game projects engineer should have knowledge of multiplayer and creating a multiplayer game. Today, multiplayer games are a large sector of the industry. The world of online gaming is constantly evolving thanks to new technologies such as cloud gaming and VR/AR with multiplayer components. Understanding how to develop these types of games potentially attracts more players. Accordingly, developers should understand the algorithms and methods of network programming. It will allow them to address multiplayer issues such as latency, preventing cheating, and ensuring a smooth and seamless experience for all participants. Balancing the gameplay for multiple players with potentially different skill levels, developing the game ergonomics that function in an online environment, player development and reward systems are also important components of a game application developer.

Communication skills. The ability to communicate effectively with the development team, willingness to cooperate and exchange ideas. Today, game development is a process performed by a team of programmers, artists, designers, sound engineers, and testers. Each of them must be able to clearly express their ideas, explain technical concepts, and collaborate effectively with micro- and large teams. Complex games require the creation and maintenance of project documentation. Since game development is an iterative process, a developer must be able to give and receive constructive criticism. They must be able to clearly articulate their ideas, be open to suggestions and improvements, and be able to communicate with different team members, managers, or external partners.

Project management skills are crucial for game developers, even for those who are not the direct project manager. As a result, each of them needs knowledge of project management processes and the ability to plan, coordinate, and monitor teamwork to varying degrees. Project management skills help developers to effectively plan, schedule, prioritize project tasks, effectively distribute them among team members according to their skills and capabilities, and track their progress. Project management methods help developers establish clear communication between individual micro-teams or departments. In addition, developers should be able to identify potential risks, develop contingency plans, and adapt to changing circumstances. Persistence, creativity and innovation are the cornerstones of success for a modern game developer. This competency primarily includes the ability to generate (GenId) new ideas and implement (ImpId) them into reality. Creative and innovative gaming projects stand out from the crowd, attract users' attention, and push the boundaries of what is possible in terms of gameplay and player immersion. Such applications attract many players, offering them new impressions and experiences. However, the developer should remember that creativity and innovation should be balanced with other factors such as functionality, performance, project management, etc.

Taking as a basis the interdisciplinary model of responsible management competence [28], considering the above components, we propose the following basic structure of professional competencies of game application developers (figure 1).

Due to the limited space of the figure, we have summarised the most important components of each competency described above in the lower blocks. In general, our model includes competencies, some of which were identified in the analyzed studies. In the author's model, they are systematized by components. The model emphasises computer science and applied training in using modern tools for creating game content.

The implementation of the competence model involves the use of methods that were identified in the process of analyzing sources:

- Repeated learning activities to improve competencies in creating algorithms, working with mechanics, and testing game applications.
- Project-based learning is one of the most effective methods for teaching programming, design, 3D graphics, soft skills development, and collaboration.
- Brainstorming methods should be used to develop competencies in designing game applications and determining criteria and indicators for testing them.
- Case studies of the methodology, in particular, on solving specific problems. It applies to competencies in the development and debugging of game projects and the use of AI services.

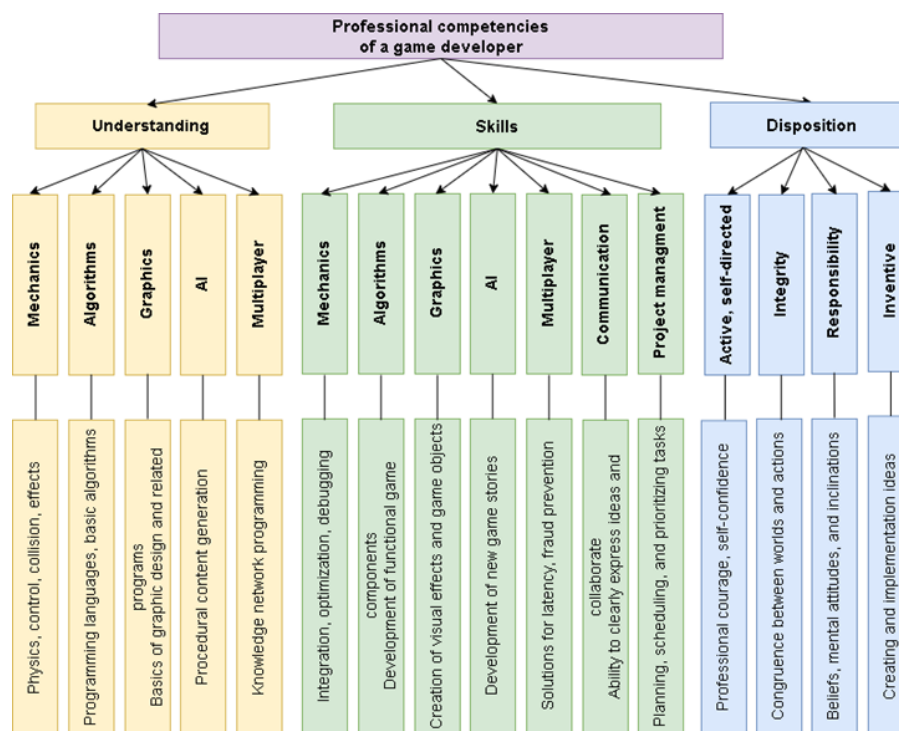


Fig. 1. Model of professional competencies of game application developers

CONCLUSIONS

The study has solved the set tasks and obtained the following results:

1. The analysis of domestic and foreign experience in training specialists in developing game projects was carried out. It showed that the problem of developing the competencies of computer game development specialists is relevant in the scientific literature and Internet sources and requires further research.

2. The key competencies, such as understanding programming, game mechanics, computer graphics, AI, communication, project management skills, persistence, creativity and innovation, were identified.

3. A model for forming competencies of computer game development specialists has been developed. It combines key competencies into such groups as understanding, skills and dispositions.

Summarizing the results of this study of the professional competencies of specialists in game projects engineering, they have practical significance for many interested parties:

1. Game developers and companies in the game industry can use these results to improve training processes. Knowing what competencies are needed to be successful in the games industry can help developers create more effective employee training programs.

2. Specialists in the field of training and education can use these results to create new training programs aimed at developing the professional competencies of students and young professionals in the field of engineering game projects.

3. Government institutions can use these results to form strategies for developing the gaming industry and to promote the development of relevant professional competencies among specialists.

Therefore, the research results have a wide application in practice, making them significant for various spheres of activity. In game project engineering, the professional competencies of specialists are a combination of technical and technological knowledge and skills, analytical thinking abilities, communication skills, teamwork and project management abilities. To work successfully in the field of game projects, specialists must have knowledge of various software platforms, technical and graphic tools, as well as the ability to program and test games. Knowledge

of game development processes is an essential factor in forming of professional competencies of specialists. This involves understanding the stages of game design, development, testing and release, as well as knowledge of project management and problem-solving methods. In addition to technical knowledge and skills, specialists in the field of game project engineering must have communication skills and the ability to work collectively. These are key factors for successful teamwork. The results of the research can be helpful in the training of specialists in the field of engineering game projects, as well as for recruiting and selecting candidates for work in this field. They can also be useful for improving curricula and training programs for specialists in this field.

The study has certain limitations. We assume that the training of the target group for which the model was developed is formal education for university students. The disciplines of the relevant educational programs should cover the formation of competencies of our proposed model. Since forming the competencies defined in the model requires modern hardware and software, this may also be a limitation of the author's model. Cloud computing and virtual reality technologies can partially solve such problems [29; 30; 31; 32].

Prospects for further research are to verify the effectiveness of the model by experimental and statistical means. It will allow us to confirm the general hypothesis of the study.

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ПРОФЕСІЙНІ КОМПЕТЕНТНОСТІ ФАХІВЦІВ У ГАЛУЗІ РОЗРОБЛЕННЯ КОМП'ЮТЕРНИХ ІГОР

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Анотація. Галузь розроблення комп'ютерних ігор стала важливим сектором глобальної цифрової економіки, який швидко розвивається, що вимагає всебічного розуміння професійних компетенцій у фахівців з інженерії ігрових проєктів. Дослідження вивчає моделі навичок, знань і диспозицій, необхідних для фахівців з розробки ігрових додатків. Вони були отримані на основі аналізу вітчизняних і міжнародних освітніх програм, галузевих стандартів і професійних рамок.

Стаття використовує методологію, що передбачає огляд літератури, спостереження і аналіз конкретних ситуацій, проєктування педагогічних систем та моделей. У дослідженні визначено та синтезовано структуру професійних компетентностей за кількома ключовими вимірами: технічні, когнітивні, творчі, міжособистісні та управлінські. Запропоновано модель, яка об'єднує ці виміри у структуровану систему, що підкреслює взаємопов'язаний характер знань, навичок і ціннісних ставлень і переконань, необхідних в інженерії ігрових проєктів. Модель підкреслює важливість міждисциплінарного підходу, поєднуючи технічні навички з м'якими навичками та творчими здібностями.

Результати дослідження мають важливе практичне значення для зацікавлених сторін. Розроблена модель дає уявлення про стратегії цілеспрямованого навчання студентів, які здобувають освіту з комп'ютерних наук та інженерії програмного забезпечення. Заклади вищої освіти можуть використовувати її для розробки більш комплексних та орієнтованих на виробництво освітніх програм.

Основними обмеженнями дослідження є зосередженість на формальній університетській освіті та потенційні технологічні обмеження у впровадженні комплексних навчальних програм. Дослідження припускає, що хмарні обчислення та технології віртуальної реальності можуть пом'якшити деякі з цих обмежень, пропонуючи інноваційні рішення для розвитку навичок.

Ключові слова: розробка ігрових проєктів; професійні компетенції в розробці ігрових додатків; модель професійних компетенцій.